DOCUMENT RESUME

ED 363 021 EC 302 471

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TITLE	The Stroop Effect in English: Evidence for Enhanced Attentional Control in Deaf Bilinguals.
PUB DATE	Apr 93
NOTE	11p.; Paper presented at the Annual Meeting of the American Educational Research Association (Atlanta, GA, April 12-16, 1993).
PUB TYPE	Speeches/Conference Papers (150) -- Reports - Research/Technical (143)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Attention Control; *Cognitive Processes; *Color; *Comprehension; Congenital Impairments; *Deafness; Reading Skills; Sign Language
IDENTIFIERS	*Stroop Effect

ABSTRACT

This study investigated the Stroop effect with deaf and hearing bilingual individuals and whether there is a positive relationship between the Stroop effect and English language proficiency of deaf bilinguals. The Stroop effect refers to the interference caused by incongruent semantic information in naming colors (e.g., when subjects must name the ink color of the word "red" printed in green ink). Subjects were 16 congenitally, severe to profoundly deaf American college students who were fluent in sign language. In addition eight hearing fluent signers were also tested. The response times and accuracy on a color-word matching task were evaluated. Both deaf and hearing signers showed the expected general Stroop effect. However, deaf signers were better than hearing signers in suppressing interference created by incongruent lexical information. The magnitude of the Stroop effect was not related to English reading skills in deaf students. (DB)

The Stroop effect in English: Evidence for Enhanced Attentional Control in Deaf Bilinguals

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Paper presented at the American Educational Research Association (AERA) Conference, Atlanta, GA. April 12-16, 1993.

The Stroop Effect

Abstract

The Stroop effect refers to the interference caused by incongruent semantic information in naming colors and is generally thought to reflect automaticity in semantic processing. This study investigated the Stroop effect in English for congenitally profoundly deaf American college students who were fluent signers and hearing sign language interpreters who were English native speakers by measuring their response times and accuracy in a color-word matching task. Both deaf and hearing signers showed the expected general Stroop effect. However, deaf signers were better than hearing signers in suppressing interference created by incongruent lexical information. The magnitude of the Stroop effect was not related to English reading skills in deaf students.

The Stroop effect refers to the interference caused by incongruent semantic information in naming colors, e.g., when subjects must name the ink color of the word *red* printed in green ink. In the classic Stroop color-word test (Stroop, 1935), the time taken by a subject to name a list of 100 color squares, is compared with the time taken to name ink colors of words which spell incongruent color names. Generally, subjects take longer to name ink colors of incongruent words than to name color squares. The Stroop effect has been studied extensively in many different populations, using many variations of the original task and response modes. In a comprehensive review MacLeod (1991) noted that the Stroop effect occurs in monolinguals and bilinguals in all languages tested, and that it appears at all ages. Some studies have shown that the Stroop effect in English occurs for deaf people too (e.g., Vaid & Corina, 1989). The Stroop effect appears to be due to the inability of subjects to ignore information present in words. This notion is supported by the finding that when words are congruent with ink colors, a facilitation effect occurs. However, it is not as great in magnitude as the interference effect (see MacCleod, 1991).

Congenitally and profoundly deaf people vary considerably in their proficiency in English and therefore, extensive English language training is routinely given to deaf students at all educational levels. What is only recently being recognized is that many deaf people are also fluent in American Sign Language (ASL), the language of the Deaf community communicated in a visual-spatial mode. Thus, many American deaf adults can be viewed as bilinguals learning or using English as a second language in a culture where English is dominant. Furthermore, it is possible that these bilinguals have developed special strategies in processing English since they receive it primarily through the visual mode and may respond to the Stroop interference task differently than hearing bilinguals.

This study specifically investigated whether deaf and hearing bilinguals differ in the

magnitude of the Stroop effect in English, and whether there is a positive relationship between the Stroop effect and English language proficiency of deaf bilinguals . An important feature of this study is the use of fluent signers which ensured that both hearing and deaf subjects were bilinguals. Since deaf people vary in their speech intelligibility and motor speech response time, the standard Stroop color-word test was not usable. A color-word matching task presented visually on a CRT and requiring only a manual response was used for this study.

Method

Subjects. Sixteen congenitally, severe to profoundly deaf college students (10 females and 6 males) attending the National Technical Institute for the Deaf (NTID) were tested (ages= 19-28 years). The group mean pure tone average (PTA) hearing loss in the better ear at 500-1000-2000 Hz (ANSI, 1969) was 102.6 dB (*sd*= 8.5 dB HL, *range*= 85-115 dB). All deaf subjects were fluent signers and learned ASL before age 10. The group mean score in grade equivalents on the California Reading Comprehension Test (Tiegs & Clark, 1963) was 9.0 (*sd*= 1.2, *range*= 7.2-11.4). The group mean score on the Michigan Test of English Language Proficiency (1977) was 66.3 (*sd*= 14.3, *range*= 50-86). Eight hearing fluent signers at NTID (6 females and 2 males) who have worked as trained professional interpreters for the deaf for at least 2 years were tested (ages= 21-38 years). All subjects had no known history of neurological problems and had normal binocular vision.

Experimental Design & Procedure. Subjects participated in a color-word matching task. On each experimental trial, each subject indicated with a button press whether the second of two successively presented stimuli correctly named the color that the first stimulus was drawn in. Reaction time (RT) and accuracy were measured in three conditions.

In the first condition (Baseline condition), each trial consisted of a filled colored square (red, green, yellow, or blue) followed by a color name printed in white. Each trial type was

repeated three times for a block of 12 trials. In the second condition (Facilitation condition), each trial consisted of a color name (red, green, yellow, or blue) printed in the color named by the word, followed by a color name printed in white. Each trial type was repeated three times for a block of 12 trials. In the third condition (Stroop interference condition), each trial consisted of a color name (red, green, yellow, or blue) printed in a different color from the color named by that word, followed by a color name printed in white. The second stimulus matched either the color named by the first stimulus (Lexical Match), or the color the first stimulus was drawn in (Ink-Color Match). There were a total of 24 possible such stimulus pairs. These 24 stimulus pairs were duplicated and presented in two balanced and randomly rearranged blocks of 24 trials each. In total, each subject responded to 72 trials. A practice block of 8 trials using different color-word pairs (purple and orange) preceded each condition.

Each subject was tested individually in all conditions. Instructions were signed and spoken for deaf subjects and given orally to hearing subjects. In all conditions the subject initiated a trial by a keypress with the right thumb. Each stimulus was presented for 200 ms with a 500 ms blank interstimulus interval. The subject then pressed a key to indicate *yes* or *no*. RT was measured from the onset of the second stimulus and a maximum of 1800 ms was allowed for the response. Subjects received feedback after each block regarding their response accuracy. Extensive counterbalance and randomization procedures were used.

Results and Discussion

The average error rate was low (7.5% for deaf signers and 6.6% for hearing signers). The groups did not differ in overall accuracy ($t < 1$). Only correct RTs were analysed. The group mean RTs for all conditions are plotted in Figure 1. Since it was possible to specify a limited number of a priori research questions, planned comparisons were carried out separately for the two groups to examine the relevant interference and facilitation effects.

For the deaf group the Baseline condition was significantly faster than the Stroop Ink-Color Match ($F(1,66)= 8.87$, $p< .01$) and the Stroop Lexical Match ($F(1,66)= 7.7$, $p< .01$). Similarly, for the hearing group, the Baseline condition was significantly faster than the Stroop Ink-Color Match ($F(1,66)= 5.4$, $p< .05$) and the Stroop Lexical Match ($F(1,66)= 32.3$, $p< .0001$). There was also a strong trend towards the Facilitation condition being faster than the Baseline condition ($F(1,66)= 3.8$, $p= .054$) for the deaf group suggesting that access to lexical information occurred even though the task did not require it. These results are consistent with previous studies on hearing people that have used a manual response mode to measure the Stroop facilitation effect (see MacCleod, 1991). Although there was no significant difference between the Facilitation and Baseline conditions for the hearing group, the effect was nearly as large numerically as for the deaf subjects. Considering that this effect is clearly expected theoretically, it is probable that the statistical power to detect the effect was compromised by the much lower number of subjects in the hearing group.

The results of these planned comparisons showed that a computer controlled Color-word matching task using a manual yes or no response was appropriate to measure the Stroop interference effect in both deaf and hearing signers. The finding that the groups showed similar RTs in the Baseline and Facilitation conditions suggests that subjects understood the task and were similarly sensitive to both the lexical and color information presented to them.

Although both hearing and deaf groups showed the Stroop interference effect, there was a significant difference in their performance on the two matching tasks that were used in the Stroop condition (see Figure 1).

Insert Figure 1 about here

The hearing group was significantly slower on the Lexical Match than on the Ink-Color Match ($F(1,66) = 8.87$, $p < .01$). Apparently, the hearing group found it hard to ignore the lexical information in making the correct no response for the Lexical Match. By contrast, the deaf group was apparently able to suppress the interference caused by the lexical match and respond equally well in both matching tasks. These results agree with the finding of Parasnis & Samar (1985) that deaf young adults were better than hearing young adults in redirecting visual attention from one location to another in the presence of irrelevant foveal information. Parasnis & Samar suggested that there may be differences in the development of attentional mechanism of deaf people compared to hearing people due to their primary reliance on the visual modality for information processing and communication which may become apparent only when the system is stressed or appropriately engaged. The results of this study offer new empirical support of this hypothesis. They suggest that congenitally deaf signers may be capable of increased attentional control not only in perceptual spatial location tasks but also in memory tasks that require processing of both non-verbal and semantic information.

To examine the relationship between the magnitude of the Stroop effect and language proficiency, two within-subject difference-score measures of the magnitude of the Stroop effect were computed. These were Ink-Color Match RT minus Baseline condition RT and Lexical Match RT minus Baseline condition RT. These two difference score measures were then correlated with the deaf subjects' scores on the California Reading Test and the Michigan Language Proficiency Test. No significant correlations were found among these measures ($r = 0$ .23). Based on these data, the Stroop effect does not seem to reflect differences in second language proficiency, although it remains possible that such a relationship may exist in earlier stages of second language learning.

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Acknowledgements

This research was undertaken during the course of an agreement with the US Department of Education. I thank Vincent J. Samar and Jeff Bettger for their help in conducting this research.

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Figure Caption

Figure 1. Mean RT for deaf and hearing signers by condition.